

## Diagnostic imaging: Morphological and eruptive disturbances in the permanent teeth

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imaging, including periapical, occlusal, panoramic, or cephalometric radiographs are essential in localization and management of morphological and eruptive disorders. However, due to their inherent limitations such as insufficient precision because of unusual projection errors and lack of information about spatial relationships, these methods are considered unreliable. Thus, the use of newer image acquisition techniques that allow comprehensive three dimensional imaging and visualization of dental abnormalities is highly recommended for making a confirmatory diagnosis. The significance of accurate endodontic, surgical and orthodontic treatment planning in dental abnormalities cannot be overstated as it pertains to critical anatomic landmarks such as proximity to adjacent teeth or the mandibular canal. The precise information on spatial relationships provided by multiplanar imaging helps the dental surgeon to establish more accurate diagnosis, management strategies and also increases the patient safety. This review highlights the use of high-end diagnostic imaging modalities in diagnosis of the various morphologic and eruptive dental abnormalities.

**Key words:** Three-dimensional imaging; Spiral computed tomography; Magnetic resonance imaging; Eruptive malformations; Morphological disturbances; Conebeam computed tomography

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### Abstract

This paper reviewed the literature on newer three-dimensional imaging techniques and their applications in diagnosis and treatment planning of various dental anomalies. Developmental anomalies can occur during any of the developmental stages and are manifested clinically after the tooth is fully formed. These dental anomalies may involve a single tooth, a group of teeth, or the entire dentition. Two-dimensional diagnostic

**Core tip:** The advent of cone beam computed tomography, Spiral Computerized Tomography and Magnetic resonance imaging in the field of dental radiology has greatly facilitated access to the internal morphology of soft tissue and dental hard tissue structures. These techniques are beneficial in viewing spatial relationship of the suspected anomalous tooth and surrounding structures. Multiplanar imaging resolves the ambiguity of conventional two-dimensional radiographs by allowing the rotation of images at arbitrary angles without image magnifications and distortions.

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## INTRODUCTION

Dental anomalies are expressed as morphological and eruption disorders. Morphological dental abnormalities occur due to disturbances during odontogenesis and it includes abnormality in number (supernumerary teeth), abnormality of tooth shape and size (dens in dente, dilaceration, fusion, root dwarfing)<sup>[1]</sup>. Eruption disturbances are mainly divided as disturbances related to time (premature eruption, delayed eruption or impactions) and disturbances related to position (ectopic eruption and transpositions).

A number of factors are responsible for eruptive and morphological dental abnormalities including genetic and congenital anomalies, metabolic disturbances, post operative complications of head and neck radiation therapy, use of chemotherapeutic agents, traumatic injuries to the primary dentition affecting the permanent tooth formation, etc<sup>[1,2]</sup>. The embryologic tooth development of teeth starts around one and half month of intrauterine life and is characterized by distinct odontogenic stages including initiation, proliferation, histodifferentiation, morphodifferentiation, apposition, and calcification. Each stage has its own significance and disturbance at any stage may result into the development of an anomaly. The development of primary dentition occurs in a protected prenatal environment and duration of deciduous teeth development is small, therefore, they are less prone to dental abnormalities than the permanent teeth.

Radiographic method is considered to be advantageous for the preoperative determination of position and nature of these dental anomalies. Conventional plain film radiographic methods such as periapical, occlusal, panoramic, or cephalometric radiographs are a de-facto standard for diagnosis and treatment planning. However, due to their inherent limitations such as insufficient precision because of unusual projection errors and lack of information about spatial relationships, these methods are considered unreliable<sup>[3,4]</sup>. Earlier, computed tomography (CT) has been used widely in maxillofacial imaging to provide detailed 3-dimensional (3D) information. It forms an integral part in diagnosis of oral and maxillofacial regions as it facilitates access to the internal morphology of dentofacial structures. Its benefits of viewing spatial relationship of the anomalous tooth with surrounding structure by the rotation of images at arbitrary angles and absence of image magnification and distortions are well recognized and widely accepted in the literature. It is considered as more desirable morphometric tool than conventional

plain film radiography<sup>[5-7]</sup>. However, it has certain limitations reducing its diagnostic reliability in dentistry including relatively low between-slice accuracy, no interslice gaps, artifacts, edge gradient effects and high radiation dose<sup>[8]</sup>. Recently, a series of cone beam computed tomography (CBCT) scans for three dimensional imaging of dentomaxillofacial region have been developed<sup>[8-13]</sup>. The aim of the study is to present a systematic review of the literature on the diagnostic imaging of the morphological and eruptive disturbances in the permanent teeth.

## DIAGNOSTIC IMAGING TECHNIQUES FOR ASSESSMENT OF ERUPTIVE AND MORPHOLOGICAL DENTAL ANOMALIES

CBCT is relatively newer image acquisition techniques that allow comprehensive multiplanar imaging and visualization of dental abnormalities in which resolution is measured in voxels<sup>[13,14]</sup>. It uses cone-shaped X-ray beam centered on a two-dimensional (2D) detector. The source-detector system performs one rotation around the object producing a series of 2D images. The 3D images are obtained by reformatting the 2D data in volume using a modification of the original cone-beam algorithm developed by Feldkamp *et al*<sup>[15]</sup> in 1984. CBCT scanners for the dentofacial region were originally developed in the late 1990s independently by Arai *et al*<sup>[16]</sup> in Japan and Mozzo *et al*<sup>[17]</sup> in Italy. CBCT has little projection effect and no magnification errors because X-ray beams are orthogonal, resulting in undistorted 1:1 measurements. It provides information for the entire craniofacial region<sup>[18,19]</sup> (Table 1).

## IMPACTED TEETH

Impaction is defined as eruption failure of a tooth to its normal site in occlusion during its normal growth period because of malposition, lack of space, abnormal habit or mechanical obstruction in its eruption trajectory. The precise localization and diagnosis of an impacted tooth is required for proper surgical access and treatment planning. Nakajima *et al*<sup>[20]</sup> demonstrated the importance of CBCT image acquisition technique in cases of delayed eruption of the maxillary left second premolars and severe impaction of a maxillary second bicuspid. CT images provided more accurate information for orthodontic diagnosis and management strategies than conventional radiographic images such as precise observation of tooth morphology, root condition, and superimposition of bone.

### 3D imaging in impacted permanent incisors

Traumatic injuries to primary dentition cause eruptive malformations in underlying permanent tooth germs as they are in a close contact with their primary predecessors<sup>[21]</sup>. It may hinder the eruption pathway of the permanent tooth germ leading to delayed or failure of

**Table 1** Role of conebeam computed tomography for assessment of eruptive and morphological disturbances

Ref.	Year	Eruptive or morphological disturbances	Tooth involved
Nakajima <i>et al</i> <sup>[20]</sup>	2005	Impaction	Maxillary second bicuspid
Walker <i>et al</i> <sup>[12]</sup>	2005	Impaction	Canine
Siraci <i>et al</i> <sup>[45]</sup>	2006	Talon cusp	Facial and lingual surfaces of a supernumerary primary tooth
Maverna <i>et al</i> <sup>[34]</sup>	2007	Impaction	Maxillary canine
Andrade <i>et al</i> <sup>[49]</sup>	2007	Root dilaceration	Maxillary right central incisor
Liu <i>et al</i> <sup>[14]</sup>	2007	Supernumerary teeth	Complete dentition
Liu <i>et al</i> <sup>[32]</sup>	2008	Impaction	Maxillary canines
Haney <i>et al</i> <sup>[18]</sup>	2010	Impaction	Maxillary canine
Patel <i>et al</i> <sup>[59]</sup>	2010	Dens invaginatus	Mandibular lateral incisor
Song <i>et al</i> <sup>[73]</sup>	2010	Fusion	Right maxillary first molar and supernumerary tooth
Gurge <i>et al</i> <sup>[24]</sup>	2011	Impaction	Upper lateral incisor
Alqerban <i>et al</i> <sup>[33]</sup>	2011	Impaction	Maxillary canine
Kaneko <i>et al</i> <sup>[60]</sup>	2011	Dens invaginatus	Maxillary lateral incisor
Narayana <i>et al</i> <sup>[61]</sup>	2012	Dens invaginatus	Maxillary right lateral incisor
Vier-Pelisser <i>et al</i> <sup>[62]</sup>	2012	Dens invaginatus	Maxillary left lateral incisor
Kfir <i>et al</i> <sup>[63]</sup>	2013	Dens invaginatus	Right maxillary central incisor
Kato <sup>[64]</sup>	2013	Dens invaginatus	Maxillary lateral incisor
Cantin <i>et al</i> <sup>[65]</sup>	2013	Impaction	Mesiodens
Oenning <i>et al</i> <sup>[30]</sup>	2014	Impaction	Third molar
Mahesh <i>et al</i> <sup>[50]</sup>	2014	Root dilaceration	Permanent maxillary right central incisor

eruption<sup>[22]</sup>. The effect on the underlying tooth bud is related to its stage of odontogenesis, type and direction of impact<sup>[23]</sup>.

Gurge *et al*<sup>[24]</sup> carried out CBCT imaging for comprehensive multiplanar evaluation, exact localization and conservative management of non erupted permanent upper lateral incisor with a previous history of a trauma through the primary predecessor in a 9-year-old patient. They highlighted the need for CBCT image acquisition techniques in the cases of impacted teeth where 3D visualization is necessary.

### Impacted 3rd molars

Third molars are the most frequently impacted teeth. The dental literature has revealed these teeth are usually associated with pericoronitis, cheek biting, cysts, odontogenic tumors, and external root resorption of proximal teeth<sup>[25-29]</sup>. CBCT has proven to be an efficient method for evaluation of spatial relationship in different planes before deciding on management of impacted third molars.

Oenning *et al*<sup>[30]</sup> assessed external root resorption of second permanent molars associated with impacted third molars by conventional radiography and CBCT imaging. They observed significantly higher number of cases of ERR with CBCT imaging technique and highly recommended its use in cases of impaction specially mesioangular or horizontal impactions.

### Impacted canines

Maxillary canines are the 2<sup>nd</sup> most commonly impacted teeth. Earlier tube shift technique was used to reveal the position of unerupted canine but the exact extent of displacement cannot be determined. CBCT imaging is beneficial in providing the accurate labial/palatal position and angulation of the impacted canine<sup>[3,31]</sup>.

Walker *et al*<sup>[12]</sup> assessed the spatial relationship of impacted canines with adjacent structures and root resorption of incisor with the aid of 3D images produced from NewTom QR-DVT 9000. 3D volumetric imaging of impacted canines depicted the size of the follicle, inclination of the long axis of the tooth, relative buccal and palatal positions, bone covering the tooth, 3D proximity and resorption of roots of proximal teeth, local anatomic considerations and stage of dental development.

Liu *et al*<sup>[32]</sup> determined the position of 210 impacted maxillary canines and resorption of adjacent incisors with CBCT images. The angular and linear measurements depicted the spatial variations of the impacted canines which provided the picture for three dimensional relationships of the impactions relative to the adjacent dental arch.

Haney *et al*<sup>[18]</sup> compared differences in the diagnosis and treatment planning of impacted maxillary canines with traditional 2D imaging techniques and 3D CBCT volumetric images. The results yielded that the clinicians' confidence in the accuracy of diagnosis and treatment plan was statistically greater for CBCT images ( $P < 0.001$ ).

Alqerban *et al*<sup>[33]</sup> compared two CBCT systems vs traditional 2D imaging for assessing the location of impacted maxillary canine and identification of root resorption and observed that CBCT was more sensitive than panoramic radiography.

Maverna *et al*<sup>[34]</sup> evaluated different radiographs for the localization of impacted maxillary canines [orthopantomography (OPT), laterolateral and postero-anteriorteleradiography, parallax method, laterolateral, occlusal radiography, computerized axial tomography, cone beam CT]. They concluded that CBCT provided elements which escaped during traditional radiographic analysis and

is therefore indicated in case of impacted teeth or cranio-facial structural anomalies.

## ECTOPIC ERUPTIONS

Transposition is a rare type of ectopic eruption where a permanent tooth erupts in the position normally occupied by another permanent tooth<sup>[35-39]</sup>. Transposition are more frequently observed in upper arch (68.5%-76%) than in lower arch<sup>[39-42]</sup>. Maxillary canine and the first premolars are most commonly transposed<sup>[40]</sup>. The ultimate success of the treatment plan is based upon accurate assessment and precise localization of the transposed teeth. Ericson and Kurol<sup>[43]</sup> reported that, in a sample of Swedish children, conventional periapical radiography successfully localized only 80% of ectopic canines. Rest 20% required tomography for exact localization especially in cases with overlapping lateral incisor (Table 1).

## TALON CUSP

Talon cusp is an unusual morphological dental anomaly that is most commonly seen in the form of an accessory cusp-like structure projecting from the lingual or facial surface of anterior teeth<sup>[44]</sup>. A talon cusp is morphologically well-delineated. The appearance of projection is conical and resembles an eagle's talon. Talon cusp may occur in both primary and permanent dentitions. It can occur in maxillary or mandibular anterior teeth. It is seen in both sexes<sup>[45]</sup>.

Siraci *et al.*<sup>[46]</sup> demonstrated unusual presentation of a talon cusp, occurring on both the facial and lingual surfaces of a supernumerary primary tooth. Existence of pulpal extensions was investigated using cone beam X-ray CT. It revealed distinct existence of pulpal extensions within the facial and palatal talon cusps. According to Mader and Kellogg<sup>[47]</sup>, it was very difficult to distinguish the existence of a pulpal extension, which was confirmed in this case. Other two radiographs were taken from different angles but the interpretation of accessory pulp horns was uncertain which necessitated the utilization of a cone-beam CT for a correct diagnosis.

## ROOT DILACERATION

Dilaceration is a developmental anomaly which occurs as a result of an abrupt change in the axial inclination between the crown and the root of a tooth. But the criteria in the literature for recognizing root dilaceration vary. Two possible causes of dilacerations are trauma and developmental disturbances. It has also been proposed that it might be associated with some developmental syndromes. Dilaceration is seen in both the permanent and deciduous dentitions, and it is more commonly found in posterior teeth and in the maxilla. Periapical radiographs are commonly used to diagnose the presence of root dilacerations<sup>[48]</sup>.

Andrade *et al.*<sup>[49]</sup> evaluated tooth displacement and

root dilaceration after trauma to primary predecessor by CT. The tomograms were analyzed using a dental computed tomography software program in order to evaluate the root formation of the upper right permanent central incisor and its position in the anterior alveolar process.

Mahesh *et al.*<sup>[50]</sup> described the use of CBCT for the 10-year-old patient with the complaint of non-eruption of the permanent maxillary right central and lateral incisors. A cone-beam CT scan was performed to assess the extent of dilaceration, if any, and to aid in the creation of a suitable treatment plan. It revealed palatal displacement of the crown and a gradual curvature in the apical 1/3<sup>rd</sup> of the root of right central incisor.

## SUPERNUMERARY TEETH

Supernumerary teeth are a relatively frequent disorder of odontogenesis characterized by an excess number of teeth. It can be found in any region of the dental arch both in the primary and permanent dentition. Associated complications are failure of adjacent teeth to erupt, displacement and crowding of the adjacent teeth, abnormal diastema, root resorption.

Liu *et al.*<sup>[14]</sup> used CBCT for evaluation of 626 supernumerary teeth in 487 patients. The ability of CBCT to visualize dental and skeletal structures relative to supernumerary teeth was also evaluated. A new system was proposed to classify the complex spatial location of supernumeraries in the maxillary anterior arch based on evaluation with CBCT. Type I, type II, and type VI were located palatal to the neighboring incisors in a variant craniocaudal position. Type III and type IV were seen within the dental arch, oriented normally, inverted, or in cross section. Type V was the supernumerary teeth located labially and superior to the incisor root and is rarest in occurrence. This classification system may yield an accurate picture for the 3D relationship of the supernumeraries relative to the adjacent dental structures, which is important during surgical or orthodontic evaluation. CBCT imaging yields accurate 3D pictures of local dental and bony structures, which is helpful for pretreatment evaluation of supernumerary teeth.

Supernumerary premolars are a rare anomaly in the maxillofacial complex. Its rarity and complex characteristics often makes it difficult to treat. CBCT plays an important role in assessment of both the location and the typing of supernumerary teeth<sup>[14,51,52]</sup>. Thus, CBCT is crucial for exact localization which assists in proper treatment planning, and for the surgical approach in cases of multiple supernumerary teeth<sup>[53]</sup>. The benefits of CBCT imaging being low radiation dose and accurate diagnosis of the complex pathology in case of supernumerary teeth<sup>[54]</sup>. Odontomas are odontogenic tumours, resulting from epithelial growth and differentiated mesenchymal cells, clinically asymptomatic, and often associated with changes to the eruption of the permanent dentition. In recent years,



CBCT has been used in the diagnosis and treatment planning of this condition<sup>[55]</sup>.

## DENS INVAGINATUS

Dens invaginatus (DI) is a dental developmental anomaly that results from invagination of the enamel organ into the dental papilla prior to the mineralization phase<sup>[56]</sup>. The cavity that forms in the case of dens invaginatus may serve as an external route of communication with the pulp or periapical tissues through the foramen caecum. The complexity of the internal anatomy in the case of dens invaginatus creates clinical challenges. Conventional periapical radiographs provide limited information regarding the anatomical configuration. The 3D imaging (CBCT) helps in identifying the morphology of the individual dens so that appropriate treatment planning and treatment options can be selected<sup>[57,58]</sup>.

Patel *et al.*<sup>[59]</sup> reported the use of CBCT in the assessment of chronic periradicular periodontitis associated with an infected invagination in an immature mandibular lateral incisor tooth. A CBCT scan revealed that there was no communication between the invagination and the main root canal. Endodontic treatment was carried out on the invagination. It was observed that the true nature of dens invaginatus cannot be estimated from conventional radiographs accurately. Cone beam computed tomography is a useful diagnostic tool in the management of dens invaginatus.

Kaneko *et al.*<sup>[60]</sup> described the use of CBCT to diagnose Oehlers' type III dens invaginatus in a maxillary lateral incisor. The CBCT scans demonstrated inaccessible and unfilled canal and invagination areas because of complex internal morphology. It was characterized by C-shaped cross-sectional canal configuration with constrictions at different points in different root levels and a prominent intraradicular cavity that was communicated with the enamel-lined invagination and opened into the apical periodontium. It was however judged that further endodontic treatment of the same was not feasible. CBCT helped in the diagnosis thus decision of avoiding further intervention was made that could have been difficult to negotiate.

Narayana *et al.*<sup>[61]</sup> used CBCT to aid in the diagnosis and treatment-planning phase in 11-year-old male who reported for the treatment of maxillary right lateral incisor. 3D imaging helped in identifying the morphology of the individual dens which further guided the selection of the treatment provided. The morphology of the dens invaginatus was identified, and a periapical radiolucent area was detected that was not visible on a standard periapical radiograph.

Vier-Pelisser *et al.*<sup>[62]</sup> presented the case of a maxillary left lateral incisor with Oehlers' type III dens invaginatus in which CBCT was used as an adjunctive resource in the diagnosis and in the planning and 2-year follow-up of the nonsurgical/surgical treatment. The CBCT scans revealed that the periapical radiolucency was significantly larger than seen radiographically and

the increased thickness of the buccal cortical plate was also seen.

Kfir *et al.*<sup>[63]</sup> investigated the use of 3D plastic models, printed CBCT data, for accurate diagnosis and conservative treatment of a complex case of dens invaginatus. The CBCT scan provided with the information about the true nature of invagination and its relationship to the main canal. It was useful for demonstrating how the invagination had compressed the pulp space of the main canal at different levels which led to irregular main canal with a cross-section resembling a thin crescent encircling the invagination. It was also seen that there was no communication between the invagination and the pulp space.

Kato<sup>[64]</sup> described a case of surgical and non-surgical endodontic therapy for a maxillary lateral incisor with type III dens invaginatus with necrotic pulp and an associated large periradicular lesion. CBCT was used for three-dimensional observation of the morphological details of this area. It was observed that even complicated cases of dens invaginatus can be diagnosed and treated using non-surgical root canal management with the help of CBCT.

Dens invaginatus can also be associated with other abnormalities such as dysmorphic mesiodens. Though this condition can be detected by chance on the conventional radiography, the three-dimensional nature and the exact morphological patterns of DI can be determined by CBCT. Cantin *et al.*<sup>[65]</sup> presented a morphological study of impacted mesiodens in a 9-year-old girl in whom the three coronal invaginations were detected only by CBCT.

The presence of double dens invaginatus is extremely rare. Understanding the type, extension, and complex morphology of dens invaginatus is essential for the proper treatment planning. Advanced imaging techniques, such as CBCT are very helpful in diagnosis of these complex anatomic variations as they give the 3 dimensional images unlike the conventional radiographic methods<sup>[66]</sup>.

## FUSION

Fusion also known as synodontia or false germination; occurs due to the union of 2 or more separately developing tooth germs at the dentinal level, presenting a single large tooth during odontogenesis, when the mineralization of crown is yet mineralized<sup>[67]</sup>. The prevalence of tooth fusion is estimated to be 0.5%–2.5% in primary dentition<sup>[68]</sup>, whereas it is lower in permanent dentition. When fusion takes place between a normal tooth and a supernumerary tooth, the fused teeth shows an anomalous broad crown<sup>[69]</sup>. The pulp chambers and root canals can be joined or separated, depending on the stage of development when fusion took place<sup>[70]</sup>. Radiographic examination of fused teeth is important for management of endodontic problems. But the conventional intraoral periapical views produced only a 2D image which resulted in the superimposition

**Table 2** Role of spiral computerized tomography in diagnosis of morphological disturbances of teeth

Ref.	Morphological disturbance	Tooth involved
Gopikrishna <i>et al</i> <sup>[79]</sup>	Unusual morphology of a single root and a single canal	Maxillary first molar
Ballal <i>et al</i> <sup>[77]</sup>	Fusion	Mandibular second molar with a paramolar
Metgud <i>et al</i> <sup>[78]</sup>	Single conical non bifurcated posterior root forms, taurodontism, dens invaginatus, labial lobes of the canines, pyramidal cusps of the premolars, dens evaginatus of the molar crowns, and localized reduction in tooth size	Entire dentition

of structures<sup>[71]</sup>. Nowadays a new diagnostic tool, CBCT, is being used in endodontics. Matherne *et al*<sup>[72]</sup> reported that CBCT imaging is useful in identifying root canal systems.

Song *et al*<sup>[73]</sup> discussed the endodontic management of a supernumerary tooth fused with a right maxillary first molar. They used CBCT for proper imaging of the same. Proper diagnosis and treatment planning can be done with the use of CBCT that further ensures predictable and successful results.

Ferreira-Junior *et al*<sup>[74]</sup> reported a case of fusion between an impacted third molar and a supernumerary tooth. The surgical intervention was carried out, with the objective of eliminating the dental elements. Proximity to the mandibular ramus made the final diagnosis difficult with panoramic radiography. Thus, CBCT was used to determinate the final diagnosis and also to help in the further surgical planning. It was observed that cone-beam computed tomography resulted in precise 3D information which was not possible with conventional radiography (Table 2).

Recently, a new CT technique, *i.e.*, spiral computed tomography (SCT) also called volume acquisition CT, has been developed which has a significant advantage. It uses simultaneous patient translation through the X-ray source with continuous rotation of the source-detector assembly<sup>[75]</sup>. SCT acquires raw projection data with a spiral-sampling locus in a relatively short period<sup>[76]</sup>. The data can be viewed as conventional transaxial images without any additional scanning time. This technique makes reconstruction of overlapping structures at arbitrary intervals possible. Thus the ability to resolve small subjects is increased.

The unique arrangement of the gantry and rotating X-ray source assembly reduces scan times. With standard incremental CT, small objects can be missed or their detection compromised if the patient's degree of inspiration and expiration varies from scan to scan. Moreover, multiplanar and 3D image reconstructions of structures from standard incremental CT data are degraded by motion-induced misregistration artifacts<sup>[77]</sup>.

Ballal *et al*<sup>[77]</sup> reported a rare case of successful endodontic management of unilateral fused mandibular second molar with a paramolar. The rarity and complexity of the entity makes it difficult to diagnose and treat. The use of diagnostic imaging modalities such as spiral SCT helps in forming a confirmatory diagnosis and treatment plan.

Metgud *et al*<sup>[78]</sup> reported a unique case with a

unusual combination of morphological dental anomalies, including single conical non bifurcated posterior root forms, taurodontism, dens invaginatus, labial lobes of the canines, pyramidal cusps of the premolars, dens evaginatus of the molar crowns, and localized reduction in tooth size involving the entire dentition. It was not related with any other apparent systemic complication. The accurate assessment of the presence of single conical non bifurcated posterior root forms was done with the help of spiral computerized tomography.

Gopikrishna *et al*<sup>[79]</sup> reported a maxillary first molar with an unusual morphology of a single root and a single canal. An accurate assessment of this unusual morphology was made with the help of a Spiral computed tomography which was then endodontically managed.

Both case reports highlighted the use of high-end diagnostic imaging modalities such as spiral computerized tomography in diagnosis of the various morphologic abnormalities (Table 3).

3D imaging techniques are being utilized in dentistry beyond maxillofacial surgical planning. Dental magnetic resonance imaging (MRI) is technique that adds a third dimension to treatment planning other than on CT and digital volume tomography.

MRI, is quite new in the field of dental radiology. The technique does not use ionizing radiation and is safe when no contraindications are present such as (cardiac pacemakers, implanted cardiac defibrillators, aneurysm clips, neurostimulators, metallic foreign bodies in the eyes, *etc.*). It has no limitations in the frequency of examinations. MRI is based on the nuclear magnetic resonance phenomenon, which takes place when nuclei of certain atoms (usually hydrogen in medicine) are placed in a strong static magnetic field and absorb energy of an alternating magnetic field of a specific, resonant frequency. The use of spatially varying magnetic fields makes it possible to spatially encode the nuclei and perform tomographic imaging.

The signal measured on MRI usually originates from soft tissues and liquids in the human body. The teeth and jawbone appear black in images taken by MRI due to low water content and short relaxation constants of hydrogen atoms. The dental pulp, jawbone marrow, mandibular canal containing the mandibular artery and vein and the alveolar nerve, saliva, gingiva, facial soft tissues, tongue, and palate produce a signal on clinical MRI. But there is no measurable signal from dental enamel, dentin, cortical bone, and air. The structures that do not produce any sign can also be measured indirectly from the contrast

**Table 3** Magnetic Resonance Imaging in diagnosis of eruptive and morphological dental anomalies of permanent teeth

Ref.	Morphological disturbance	Tooth involved
Tymofiyeva <i>et al</i> <sup>[81]</sup>	Impaction	Entire dentition
Tymofiyeva <i>et al</i> <sup>[83]</sup>	Mesiodens, gemination, dilacerations, transmigration, transposition	Entire dentition

with adjacent signal-emitting structures.

MRI enables 3D measurement of the mandible because of the contrast between the cortical bone and the surrounding soft tissue<sup>[80]</sup>. Impacted teeth can be visualized and their positions in all 3 dimensions can be assessed. As there is difference in contrast between the teeth and the surrounding tissue, such as the gingiva, tongue, cheek, saliva, and jaw bone marrow<sup>[81]</sup>. The most significant advantage of dental MRI is the complete absence of ionizing radiation when compared to other 3D imaging techniques.

Tymofiyeva *et al*<sup>[81]</sup> discussed economic aspects and technical properties of MRI compared with cone-beam CT in diagnosing impacted teeth. Gaudino *et al*<sup>[82]</sup> reported that MRI shows a comparable accuracy and better visibility in the detection of teeth and periodontal anatomy compared with cone-beam CT.

Tymofiyeva *et al*<sup>[83]</sup> assessed the feasibility of MRI of dental abnormalities in 16 patients (mean age, 10.8 years). The selected patients included 3 with a mesiodens, 9 with supernumerary teeth other than a mesiodens, 1 with gemination, 1 with dilacerations, 1 with transmigration, and 1 with transposition. MRI was found to be a suitable imaging modality for the diagnosis of dental abnormalities in children and for orthodontic treatment and surgical planning. MRI had various advantages when compared with conventional radiographic methods such as 3 dimensionality and complete elimination of ionizing radiation, which is relevant for repeated examinations in children.

## CONCLUSION

In conclusion, the results of this review showed that 3D imaging techniques are crucial for exact localization and provides precise three dimensional information on spatial relationships by depicting the size of the follicle, inclination of the long axis of the tooth, relative buccal and palatal positions, bone covering the tooth, proximity and resorption of roots of proximal teeth, local anatomic considerations and stage of dental development. Thus, the use of newer image acquisition techniques such as Cone Beam Computed Tomography, Spiral Computerized Tomography and Magnetic Resonance Imaging are advocated for final diagnosis and precise treatment planning of eruptive and morphological dental anomalies.

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